Capsule Report Approaching Zero Discharge In Surface Finishing

U.S. Environment Protection Agency Office of Research and Development National Risk Management Research Laboratory Technology Transfer and Support Division Cincinnati, OH 45268



Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described here under contract number 8C-R520-NTSX to Integrated Technologies, Inc. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Foreword

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory (NRMRL) is the Agency's center for investigation of technological and management approaches for preventing and reducing risks from pollution that threaten human health and the environment. The focus of the Laboratory's research program is on methods and their cost-effectiveness for prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites, sediments and ground water; prevention and control of indoor air pollution; and restoration of ecosystems. NRMRL collaborates with both public and private sector partners to foster technologies that reduce the cost of compliance and NRMRL's research provides solutions to to anticipate emerging problems. environmental problems by: developing and promoting technologies that protect and improve the environment; advancing scientific and engineering information to support regulatory and policy decisions; and providing the technical support and information transfer to ensure implementation of environmental regulations and strategies at the national, state, and community levels.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director

National Risk Management Research Laboratory

Acknowledgments

This guide was prepared by Peter A. Gallerani, Integrated Technologies, Inc., and Kevin Klink, CH2M Hill. Douglas Grosse, U.S. Environmental Protection Agency(USEPA), Office of Research and Development, National Risk Management Research Laboratory (NRMRL), served as the project officer, co-author, and provided editorial assistance. Dave Ferguson, U.S. EPA, NRMRL, served as the technical advisor.

The following people provided technical review, editorial assistance, and graphic design:

Contents

Not								
Ack			nts					
, (0)		Ū						
1	Introd	duction		1				
2	Syste	ematic	AZD Planning	. :				
2	,							
3	Process Solution Purification and Recovery Technologies							
		.1.1	Applications					
	-	.1.1	Limitations					
	•	.1.2	Secondary Stream(s)					
	-	.1.4	Diffusion Dialysis Systems	. /				
	-		ration	۱ .				
		.2.1	Applications	0				
		.2.2	Limitations					
	-	.2.3	Secondary Stream(s)					
		.2.4	Microfiltration Systems	0				
	3.3 N	/lembra	ane Electrolysis	٥.				
	3	.3.1	Applications					
	3	.3.2	Limitations	•				
	3	.3.3	Secondary Stream(s)					
	3	.3.4	Membrane Electrolysis Systems	9				
	3.4 Acid (Resin) Sorption							
		.4.1 `	Applications	10				
	-	.4.2	Limitations1					
		.4.3	Secondary Stream(s)	0				
		.4.4	Acid (Resin) Sorption Systems	1				
		3.5 Electrowinning1						
	-	.5.1	Applications	2				
		.5.2	Limitations1					
	_	.5.3	Secondary Stream(s)	3				
		.5.4	Electrowinning Systems					
	3 .6 O	other 1	echnologies1	3				
4	Rinse	Purific	cation or Concentrate Recovery Technologies1	4				
	4.1 lo	n Exch	nange1	4				
	4.	1.1	Applications1					
	4.	.1.2	Limitations1					
			Secondary Stream(s)1					
		1.4	Ion Exchange Systems					
	4.2 Reverse Osmosis1							
			Applications1	7				
		.2.2	Limitations1					
			Secondary Stream(s)1					
	4.	.2.4	Reverse Osmosis Systems	8				

	4.3 Vacuum Evaporation	···18 ···19 ···19
	4.4 Atmospheric Evaporation 4.4.1 Applications 4.4.2 Limitations 4.4.3 Secondary Stream(s)	20 20 20
	4.4.4 Atmospheric Evaporation Systems	20
5	Alternative Surface Finishing Processes and Coatings 5.1 Process Engineering and Re-engineering 5.2 Surface Finishing Properties 5.3 Surface Engineering 5.4 Surface Finishing Costs 5.5 Alternative Coatings and Processes 5.5.1 Alternative Electroplated and Electroless Coatings 5.5.2 Anodizing 5.5.3 Organic Coatings 5.5.4 Vapor Deposition 5.5.5 Thermal Spray 5.5.6 Hardfacing 5.5.7 Porcelain Enameling. 5.5.8 Metal Cladding and Bonding. 5.6 Alternative Substrates 5.6.1 Alternative Substrate Treatments 5.7 Alternative Surface Preparation 5.7.1 Alternative Stripping Processes 5.7.2 Alternative Pickling and Descaling 5.7.3 Alternative Etching 5.7.4 Alternative Cleaning 5.7.5 Alternative Cleaning Equipment 5.7.6 Forming and Fabrication	22 23 23 24 25 25 25 26 26 26 26 26 27
6	Existing Processes, Conditions, and Practices	. 28
7	Conclusions	30
8	References	. 31
Ар	pendices	
	A. Systematic Approach for Developing AZD Alternatives	32
	B. Installed Costs	37

Tables

1-1.	Section/Topic References from Section 8	2
3-1.	Technologies for Concentrated Surface Finishing Process Solution Applications	6
4-1.	Typical Ion Exchange Capacities for General Resin Types (In milliequivalents per liter, meq/L)	16
4-2 .	Technologies for Surface Finishing Rinse Applications	21
6-1.	General Approaches and Specific Techniques for Improving Existing Process Conditions and Practices	29
A-1.	Data Requirements for Characterizing Sources and Discharges	33
A-2.	Common AZD Benefits	33
A-3.	Common AZD Constraints	33
A-4.	AZD Alternative Evaluation Criteria	35
A-5.	Costs Savings and Benefits for AZD Actions	35
B-1. I	Installed Capital Cost Ranges for Typical AZD Project Approach and Size Ranges	37

Figures

3-1. Diffusion dialysis schematic	7
3-2. Microfiltration system schematic	
3-3. Membrane electrolysis schematic	10
3-4. Acid sorption system	11
3-5. Electrowinning system	12
4-1. Ion exchange system	15
4-2. Reverse osmosis system	17
4-3. Vacuum evaporation system	19
4-4. Atmospheric evaporation system	21